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Overview of Biometric and Facial Recognition Techniques

Omoyiola, Bayo Olushola
Corresponding Author:Omoyiola, Bayo Olushola

Abstract: *Security has become a major issue globally and in order to manage the security challenges and reduce the security risks in the world, biometric systems such as face detection and recognition systems have been built. These systems are capable of providing biometric security, crime prevention and video surveillance services because of their inbuilt verification and identification capabilities(Hjelmas & Kee Low, 2001). This has become possible due to technological advancement in the fields of automated face analysis, machine learning and pattern recognition (Wojcik et al, 2016). In the paper, we review some biometric and facial recognition techniques.*

Key words:*Biometrics, Face recognition, Face detection, Algorithms, Techniques, System, Verification, Identification, Faces and Image*

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I. Introduction

The field of biometrics is a branch of IT that is growing rapidly. The technologies are automated mechanisms of identifying an individual based on their biological and behavioral characteristics.
This chapter focuses on the biometric systems, facial detection and facial recognition, and evaluation of different face recognition methods.

II. Biometric Systems

The biometric system is an authentication mechanism that provides the automated identification of persons based on their unique physiological or behavioural characteristics. In other words, it is an automatic identification of a person based on his physiological or behavioural traits. Physiological traits are inherited traits which are developed in the early embryonic stages of human development. Some distinct physiological characteristics that are measurable include the hand geometry, face, fingerprint, iris, and retina of individuals. Some distinct behavioural traits which one can measure include; handwriting, voice patters and keystroke dynamics (Down & Sands, 2004; Jain A., Hong L., Kulkarni Y., 2012).
There are several kinds of unique physiological or behavioural traits of humans in existence. Some of the common biometric means of identification and verification include:

i. Fingerprint recognition: Fingerprint recognition systems utilize the ability of the biometric device to recognize the unique impressions of ridges and valleys made by an individual's finger.
ii. Hand geometry: Hand geometry solutions utilize more than 90 dimensional measurements to record an accurate spatial representation of the hand of a person.
iii. Retina scanning: Retinal scanning is electronic scanning of the retina, the innermost layer of the wall of the eyeball.
iv. Iris scanning: Iris scanning utilizes a camera mounted somewhere between three and ten feet away from an individual to snap a high definition photograph of eyes of the person. It then interprets 266 different points of data from the iris' trabecular meshwork.
v. Facial recognition: Facial recognition identifies a subject based on facial characteristics such as eye socket position, space between cheekbones, etc.
vi. Signature dynamics: Dynamic signature verification compares the signature and identifies the changes in speed, pressure and timing which during signing process.
vii. Keystroke dynamics: Keystroke dynamics technology records dwell time (which is the length of time a person holds down each key) as well as flight time (which is the time it takes to move between keys). These metrics are taken over the period of many login sessions and the two metrics give a measurement of rhythm unique to each of the users.
viii. Voice recognition: Voice recognition biometrics utilizes the process of digitizing a profile of the speech of an individual into a template voiceprint and stores it as a table of binary numbers. Then during authentication or verifications, the spoken passphrase is compared to the previously stored template.

Some other technologies that are being studied and are presently emerging include: hand vein, vein patterns, facial thermography, DNA, sweat pores, hand grip, fingernail bed, body odour, ear shape, gait, skin luminescence, brain wave pattern, footprint recognition and foot dynamics (Down & Sands, 2004; Jain A., Hong L., Kulkarni Y., 2012).

III. Facial Recognition

Face recognition is considered as one of the most successful applications in the field of image analysis (Al-Allaf, 2014). All over the world, it is used to integrate facial information into electronic passport (Jain, Ross & Prabhakar, 2004). It is also used for security and law enforcement and in entertainment and consumer electronics as a means for a natural user interface. It enhances user experience by recognizing the user and his identity and providing customized services for consumer equipments. In every face recognition system, each processing stage in the system is designed to satisfy application requirements for high performance (Zuo, 2006). Face recognition involves comparing an image with a collection of stored faces to identify the person in the input image (Al-Allaf, 2014). Factors such as shape, size, pose, occlusion, and illumination influence the process of face recognition. It has two different applications: basic and advanced. Major face recognition searches for unique landmarks such as: the width of nose, wideness of the eyes, the depth and angle of the jaw, the height of cheekbones, and the separation between the eyes, and makes a unique numerical code. Utilizing these numerical codes, the system then matches that image with another image and distinguishes how comparable the pictures are to each other. The image provenance for face recognition include pre-existing pictures from various databases and video camera signals. A facial recognition system involves face detection, feature extraction and face recognition (Abboud, Davoine & Dang, 2004; Elise, Fauvet, Memin & Bouthemy, 2005). As seen in Figure 1.

Figure 1: Processes in Face Recognition System

Facial recognition system utilizes the mono (sequential) and parallel face recognition concepts.
The sequential concept is seen when face recognition (the hardest algorithm) utilizes several steps before it commences the real recognition. A face must be detected to increase the possibility of recognition and speed up the process by choosing one location in the image. To detect a face, two steps must be done before the recognition. The first step is to resize the image to standard size (determine by the administrator), apply some filter to increase the quality, and convert the image into a compatible form. Next, face recognition. Image is uploaded in the memory with an Extensible Markup Language (XML) file to detect a face. Next is the recognition step. In recognition, the extracted face is compared with training faces when they uploading to memory and extract face features by a recognition algorithm (Zhao et al, 2003; Jafri and Arabnia, 2009). See Figure 2. For parallel face recognition process, two tasks can be done simultaneously. The process of uploading training face images in the memory and the process of getting face features from the training face images. A multithreading capability is utilized.

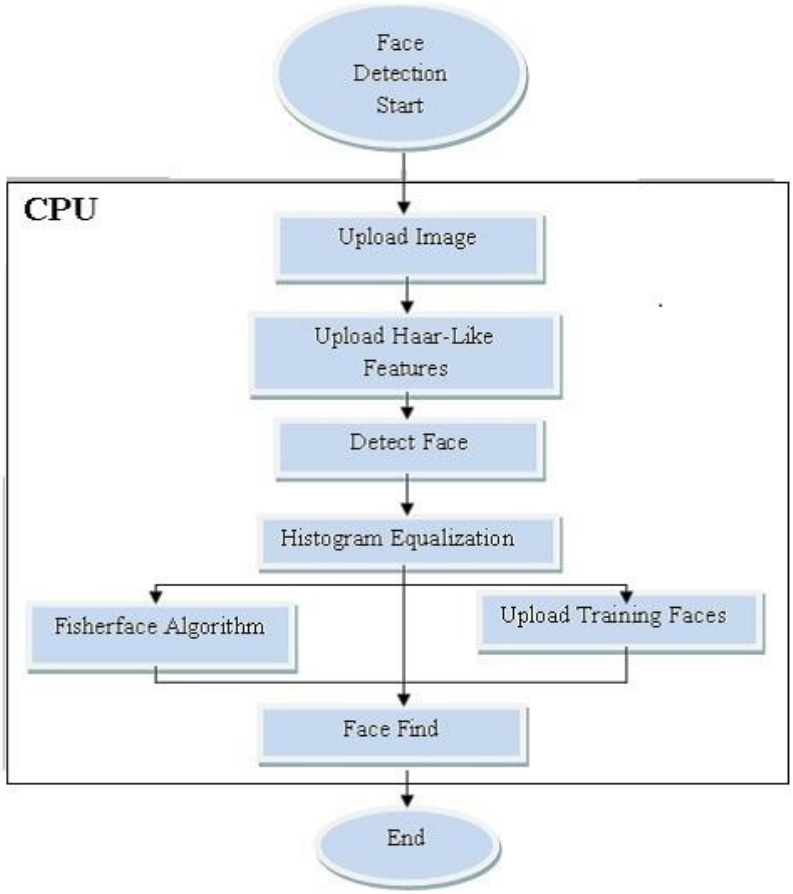

Figure 2. CPU Parallel Face Recognition (Jaber & Younis, 2014)

IV. Facial Detection

Face detection is one of the most common and long-standing problems in computer vision (Chunhua, Paisitkriagkrai and Zhang 2008). The face detection is a key step of the automatic face recognition system (Kirti and Sharma, 2017). Many algorithms exist to implement face detection. Viola and Jones (2001) proposed an algorithm, called Haar-cascade Detector or called Viola-Jones, to quickly detect any object, including human faces, using AdaBoost classifier cascades that are based on Haar-like features and not pixels. Viola-Jones algorithm is widely used in various studies involving face processing because of its real-time capability, high accuracy, and availability as open-source software under the Open Computer Vision Library (OpenCV). Viola-Jones detectors can be trained to recognize any kind of a solid object, including human faces and facial features such as eyes, and mouths. OpenCV has implemented Viola-Jones and provides a pre-trained Haar-cascade for face detection (Soni, Datar and Datar, 2017).

Guo et al (2011) did propose a two stage hybrid face detection system composed of the probability based face mask pre-filtering and pixel based. Froba and Ernst (2004) proposed a face detector consist of four phase cascade structure based on MCT-transformed images using the Adaboost learning algorithm (Li and Jain, 2011). Knowledge-based methods use facial features, such as two eyes, a nose and a mouth. Sung proposed the feature invariant methods based on facial features such as invariant to pose, lighting condition. The matching methods of the template are calculated by the correlation between a test image and preselected facial templates. Appearance based, adopts machine learning techniques to extract features from a pre-labeled training set. The Eigenface method is the most fundamental method for finding the features. The eigenface is a set of eigenvectors used for face recognition (Senthilsingh and Manikandan, 2014). It provides face recognition easy. There it is very beneficial.

V. Face Recognition Techniques

Face recognition could be classified based on their algorithms. There are different techniques of face recognition. These includes: Classical face recognition approach, holistic approach, statistical approach, model based approach, feature based, artificial intelligence approach, hybrid approach, Gabor wavelets approach, Face descriptor- based methods, 3D- based face recognition and Video- based face recognition (Naeem el, 2015; Wojcik et al, 2016).

i. The classical face recognition approach**:** The classical face recognition focuses on local structure of the manifold. These methods project face into linear subspace spanned by the eigenface images (Wojcik et al, 2016).
ii. Holistic approach: In the holistic approach, the entire face is considered as a feature for detection and recognition. It compares whole faces but ignores individual features such as mouth, eyes and nose etc. The holistic group can be divided into linear and nonlinear projection methods, or grouped as statistical and artificial intelligence methods (Naeem el, 2015; Wojcik et al, 2016). Good examples of holistic method are: Eigen faces, PCA, LDA and ICA (Parmar and Mehta, 2013).

iii. Artificial Intelligence approach: The artificial intelligence approach uses artificial neural networks to automatically recognize faces. Artificial neural networks are used to solve nonlinear problem. A non- convergent chaotic neural network recognises human faces. The Radial basis function artificial neural network is integrated with non- negative matrix factorisation (Naeem el, 2015; Wojcik et al, 2016).

iv. Statistical approach: The statistical approach involves calculating the face image density and comparing the density set values with density values of the images in the database (Naeem el, 2015). This approach involves representing patterns as features. The function of recognition is a discriminant function (Marques, 2010). Examples of statistical methods are: PCA, ICA, LDA, Discrete Cosine Transform, Kernel PCA, Gabor wavelet and Locality Preserving Projections (Marques, 2010).

v. Feature-based approach: The feature-based approach is structural in nature and it considers individual facial features such as ears, nose, eyes and mouth and matches the similarity between the images. This approach could also include hexagonal facial features. Facial recognition is done using the heuristic parameters and it is stored in a database (Naeem el, 2015; Parmar and Mehta, 2013).

vi. Gabor wavelet- based solutions:The Gabor wavelets show desirable characteristics of capturing salient visual properties such as spatial localisation orientation selectivity and spatial frequency. Different biometrics applications utilize this approach. This Gabor wavelets is widely used because Gabor features are recognised as better representation for face recognition (Wojcik et al, 2016).

vii. Face descriptor- based methods:The face descriptor-based method with local feature- based face image description offers a global description. They are evaluated in the neighbouring pixels and then aggregated to form the final global description. The aim of image descriptors is to learn the most discriminant local features that minimise difference between images of the same person and maximise those between images from other persons. These methods are discriminative and robust to illumination and expression changes. They provide compact, easy to extract and highly discriminative descriptor (Wojcik et al, 2016).

viii. 3D- based face recognition approach:3D-based face recognition extends the traditional 2D capturing process and has more potential for accuracy. The 3D process is becoming cheaper and faster. 3D sensing has greater recognition accuracy than 2D. The advantage is that its depth information is not dependent on pose and illumination, and therefore, the representation of the object does not change with these parameters, thereby making the entire system further robust. 3D- based techniques offer more robustness to pose variation problem than 2D- based ones (Wojcik et al, 2016).

ix. Model based approach: The model based facial recognition approach could be in form of 3-Dimensional or 2-Dimensional. The algorithms aim to build a human face. The 3D approach are more complex because they aim to capture the 3-dimensional nature of the human face. Examples are the elastic bunch graph matching (Marques, 2010; Naeem el, 2015)

x. Video- based face recognition:Video based face recognition employs redundancy present in the video sequence to improve still image systems. The initial stage of video- based face recognition (VFR) performs re- identification, where a set of videos is cross- matched to identify all occurrences of the person of interest. Video-based face recognition can be grouped into two categories: (i) sequence based and (ii) set based. At high level, these two approaches are differentiated based on whether or not they use temporal information. The benefit of using this approach is employing redundancy present in video to improve still image systems (Wojcik et al, 2016).

xi. Hybrid approach: This method utilize both holistic and feature based approaches (Naeem el, 2015; Parmar and Mehta, 2013; Zhao et al, 2003). Most of the time, its 3D images that are used, so the curves of the eyes sockets are observed.

VI. Conclusion

In this paper, various types of biometric techniques (e.g. fingerprints, face, retina, iris and hand geometry, fingerprints, face, retina, iris and hand geometry) were reviewed, face recognition and face recognition theories were analysed, face detection and related works were analysed and different methods of face recognition were evaluated.

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